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Update on Hadroproduced Charm at TPL

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Update on Hadroproduced Charm at TPL

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Representing the E-769* and E-791† Collaborations

Abstract

Two experiments have now been run at Fermilab using the Tagged Photon Laboratory (TPL) spectrometer with an incident hadron beam to study heavy quark physics. Results(preliminary) from the first experiment, E-769, on charm hadroproduction dependence on the target atomic number, x_F and p_t are presented. The next experiment, E-791, just completed data-taking with an upgraded spectrometer and data-acquisition system to collect a high-statistics sample of charm decays. Preliminary plots and estimates of final sample size are presented

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1 Introduction

The Tagged Photon Laboratory spectrometer is of a now conventional open geometry design for fixed-target heavy quark physics. Following a small nuclear target are up to 17 silicon microstrip detectors for finding decay vertices from heavy quark states, two magnets and 37 drift and proportional wire chambers for momentum determination, two gas threshold Cerenkov detectors for particle identification, electromagnetic and hadronic calorimeters, and muon counters behind a shielding wall. The previous experiment, E-691, used a tagged photon beam to produce heavy quark particles. The beamline has since been converted to a high-energy hadron beam. This allowed for both the study of charm hadroproduction, and an expected increase in the total number of charm decays reconstructed.

The common philosophy in these experiments is to use an open, efficient trigger for charm, delaying the application of more restrictive criteria until the off-line analysis. Such a technique both saves such event selection until after all the detector calibrations are made, and also uses cheaper, general-purpose computers, rather than expensive, single-purpose trigger processors. The trigger used requires a certain minimum amount of transverse energy be deposited in the calorimeters. To use this method, a high-rate data acquisition system is required to log the data onto tape.

2 E-769 Results

The initial experiment, E-769, concentrated on the study of charm hadroproduction. They used 250 GeV/c positive and negative hadron beams, with the beam particle type tagged by a differential Cerenkov counter and a transition radiation detector. This tagging was used to enhance the number of triggers from the kaon component of the beam. A total of 370 million triggers were recorded, with about 4,000 charm events being fully reconstructed.

The dependence of the charm cross-section with the atomic weight (A) of the target material provides information on the distance scale of the production. E-769 used a target made up of foils of beryllium, aluminum, copper and tungsten to study this scaling, which is fit to A^{α}. Their preliminary result [1] for the D^+ is $\alpha = 1.04 \pm 0.08$ and for the D^0 it is $\alpha = 0.99 \pm 0.10$, both from negative π^- data (Figure 1). These are consistent with a hard-scattering process, which requires $\alpha = 1$. They are now studying the x_F dependence of this A-dependence.

The experiment has also measured the basic x_F and p_t dependence of the D meson production. They fit the differential cross-section $d\sigma/dx_F$ as $(1 - x_F)^n$. For the D^+ they find $n = 3.8 \pm 0.4$, and that $n = 4.13 \pm 0.32$ for the D^0. As seen in Figure 2, this dependence agrees with the Nason, Dawson, Ellis[2] model for charm quark production, but disagrees when fragmentation models based on e^+e^- data are convoluted[3] with the quark production. This implies that the D mesons carry away nearly all the momentum of the charm quark. The differential cross-section as a function of p_t was first fit to $e^{-bp_t^2}$. The results were $b = 0.98 \pm 0.07$ for D^+ and $b = 0.95 \pm 0.09$ for D^0. As is shown in Figure 3, at high p_t the cross-section is fit better as $e^{-b'p_t}$.

E-769 has seen good signals for all the beam particle types (π, K and p). They

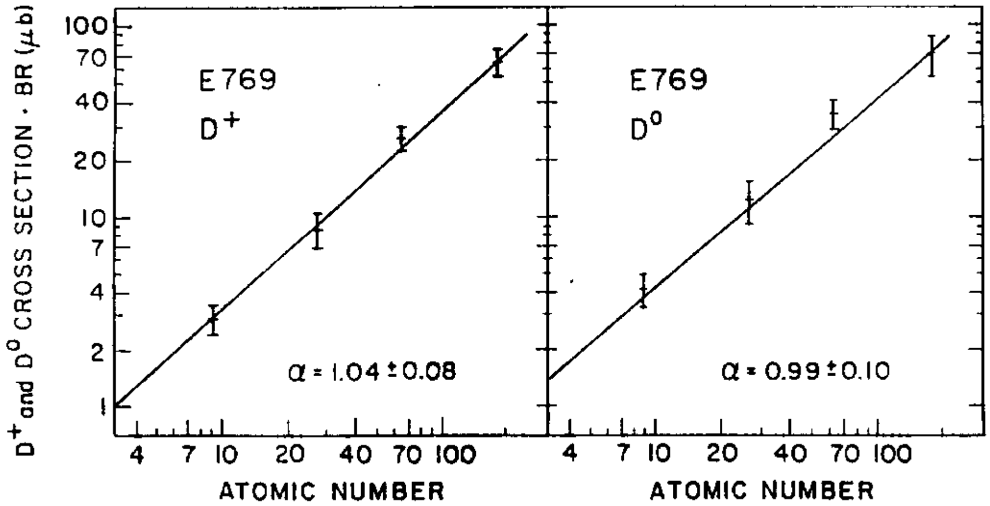

Figure 1: A-dependence of D^+ and D^0 production from 250 GeV/c π^- [1]

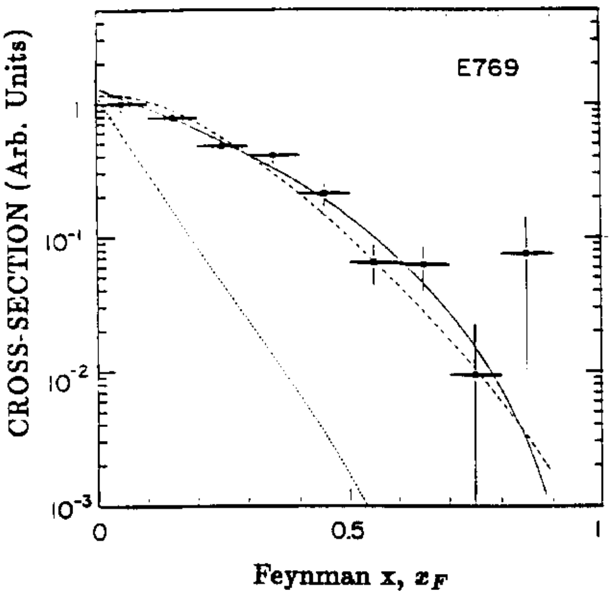

Figure 2: x_F dependence of D^+ production. The solid line is a fit to $(1 - x_F)^n$. The dashed line is the Nason, Dawson, Ellis prediction [2] for charm quark production, which is in good agreement. The dotted line is with fragmentation functions from e^+e^- data convoluted with it[3].

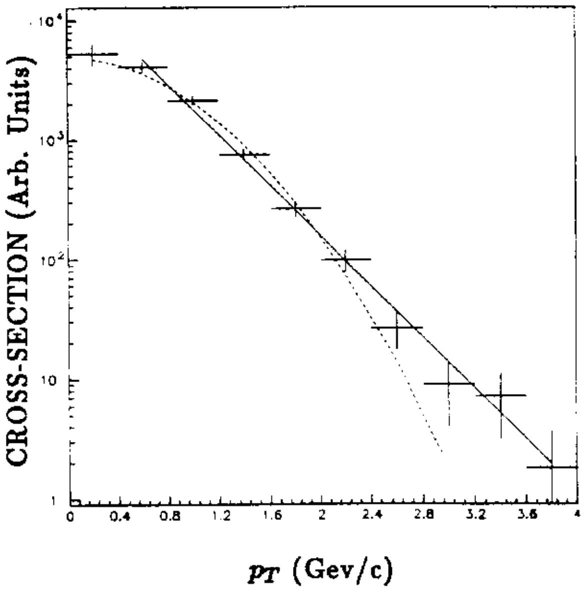

Figure 3: p_t dependence of D^+ production from 250 Gev/c π^-. The dashed line is a fit to $e^{-bp_t^2}$. The solid line, a fit to $e^{-b'p_t}$, is in better agreement with the data at large p_t.

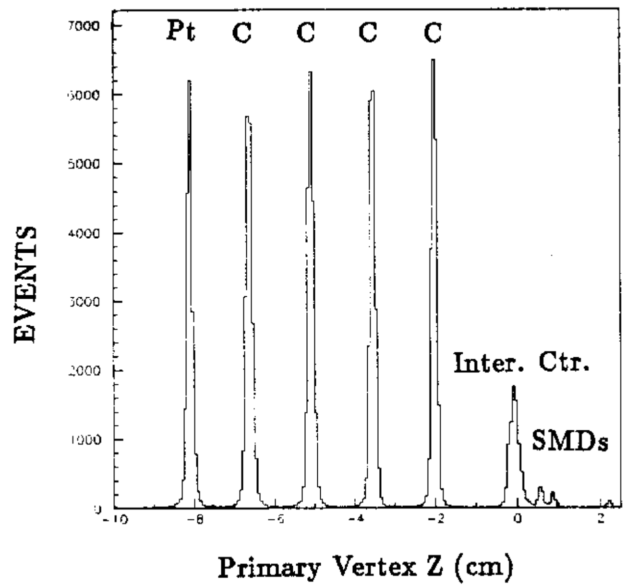

Figure 4: Distribution of reconstructed primary vertices from E-791 data, showing cleanly-separated target profiles

are now studying the relative D meson cross-sections, and their x_F and p_t dependence.

3 E-791 Results

E-791 also used the high-energy hadron beam, but this time with an emphasis on charm decay physics. E-791 used the experience of E-769 to make upgrades which would enhance the precision and charm yield of the apparatus. The beam energy was raised to 500 GeV, and more silicon microstrip planes were added to improve vertexing. The biggest change was the large increase in the data-taking rate. The readout deadtime was reduced to $50\mu s$ using fast digitizing electronics, and a highly-parallel DA system was built to record data at 9 Megabytes/s. This enabled us to record 20 billion events during the 1991 fixed-target run at Fermilab.

Preliminary analyses of some E-791 data have been made. A plot of reconstructed primary vertices(See Figure 4) reveals that the 5 target discs (1 platinum, 4 diamond) are cleanly separated. This indicates how well we can separate true secondary decay vertices between the targets from secondary interactions within the targets. We have run 100 tapes (0.5 % of our sample) through a preliminary reconstruction and have observed $D^+ \rightarrow K\pi\pi$, $D^0 \rightarrow K\pi$, and $D^* \rightarrow D^0\pi$ signals without using particle identification from the Cerenkov detectors. From these signals, we now estimate that we will have at least 100,000 fully reconstructed charm decays from our total sample.

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